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METHOD AND APPARATUS FOR TRANSMITTING INFORMATION IN VARIOUS CARRIER FREQUENCIES

The present invention is directed to a method and to an apparatus for the transmission of information in various carrier frequencies with a frequency hopping method. The apparatus and the method can thereby be implemented, for example, in a mobile station or a base station of a mobile radiotelephone system.

What is referred to as the frequency hopping spread spectrum system is known as method for the transmission of data. What is thereby to be understood by a frequency hopping spread spectrum system is a system wherein a plurality of carrier frequencies are offered for the radio transmission of data, and the carrier frequency currently employed is changed at periodic intervals. Particularly given a time-division multiplex system (TDMA), a change of the carrier frequency can ensue after every time slot of time frame of the time-division multiplex transmission. Such a frequency hopping spread spectrum system has advantages to the effect that the energy of the entire radio transmission is distributed over all carrier frequencies. This is particularly advantageous when a generally available frequency band such as, for example, the 2.4 GHz ISM (industrial, scientific, medical) band is employed. According to the applicable regulations (FCC part 15 in the USA), an upper limit for the maximally occurring energy per carrier frequency is defined for this frequency band in order to keep interference with other subscribers as low as possible. It is prescribed for the frequency change that at least 75 different frequencies must be used within a time span of 30 seconds. Further, each frequency may be used for a maximum of 0.4 seconds in 30 seconds. All frequencies must be used equally distributed on time average.

24 time slots, respectively 12 for uplink and for downlink, are defined in a 10 ms frame in the DECT standard. The FCC part 15, however, only makes a bandwidth of less than 1 MHz available in the ISM band. In order to meet this requirement, the plurality of time slots was reduced to 12 time slots in a 10 ms time frame, i.e. respectively 6 time slots for uplink and for downlink.

With 6 time slots for each direction and retaining the DECT time frame of 10 ms, each time slot would exhibit a length of 833 μs. The time s slots in the DECT standard have a length of 417 μs. Given a slow frequency hopping system, an inactive DECT time slot of 417 μs is required between two neighboring, active time slots wherein data are transmitted. In such systems, thus, only respectively 6 active time slots are employed for data transmission in each direction. If such systems that work on the basis of a slow frequency hopping are also to meet the requirements of the FCC part 15 in the ISM band, an inactive blind time slot of 417 μs must in turn be present between neighboring active time slots. This blind time slot thus has half the length of a full time slot of 833 μs, as a result whereof -- when a base time frame of 10 ms is retained -- four active time slots are offered in each frame for the respective uplink and downlink, a blind time slot being respectively transmitted between them. The four active time slots have a respective length of 833 μs, whereas the blind time slots comprises a respective length of 417 μs. Given this structure, the frequency programming for the frequency hopping in the next, following active time slot can continue to be implemented at the end of the preceding active time slot. The programmed start frequency in the next active time slot can thereby be set during the blind time slots.

To be cited as an advantage of the frequency hopping spread spectrum system is that the system becomes more insensitive to disturbances due to the offering of a great plurality of carrier frequencies. Over and above this, the security against tapping by third parties is enhanced in the system, since the third party generally does not know the carrier frequency to which a switch is made after a certain time span.

Problems can thereby occur when the plurality of usable carrier frequencies is not temporally constant. This, for example, is the case when a carrier frequency recognized as disturbed is blocked during a certain time span and, thus, is not enabled for employment and, for example, is enabled for reëmployment after a certain time span. Even given such a plurality of carrier frequencies fluctuating over time, it must be assured that, for example, the aforementioned FCC part 15 rules are adhered to.

EP-A-0 182 762 discloses a method in a telecommunication system with two transmission/reception stations that selects carrier frequencies according to the frequency hopping method, whereby new carrier frequencies from a matrix with available frequencies are selected by a generation of a sequence of random numbers that reference the position of a respective carrier frequency in the matrix and on the basis of status information for the respective frequency likewise stored in the matrix, so that they are read out [...] a next step.

GB-A-2 228 163 [...] a transmission system that is operated according to the frequency hopping method, with a plurality of networks comprising a plurality of transmission/reception devices, whereby the frequency stock is resolved into a plurality of sub-sets, so that neighboring time slots of neighboring networks are services with frequencies from different sub-sets for avoiding interference.

US-A-5,471,503 [...] a method for sampling a reception signal in a telecommunication system working according to the frequency hopping method, whereby each channel is checked for an existing transmission.

The object of the present invention is to create a method and an apparatus for the transmission of information in various carrier frequencies with a frequency hopping method wherein the various carrier frequencies are offered in a simple and effective way.

This object is achieved by a method and an apparatus for the transmission of information in various carrier frequencies with a frequency hopping method according to the independent claims. Advantageous developments of the present invention are recited in the respective subclaims.

For transmission of information in various carrier frequencies with a frequency hopping method, a random sequence of a plurality of N possible carrier frequencies fx is offered in addresses 1 through N of a table according to the present invention, whereby the N possible carrier frequencies are subdivided into n sub-groups. At least a part M of the N carrier frequency values fx is then periodically repeatedly read out from the table, whereby the carrier frequency values fx are sequentially read from the corresponding addresses within each sub-group, and the

sub-groups are read out in a specific sequence, whereby $M \leq N$ applies. Subsequently, information are transmitted in the carrier frequencies corresponding to the carrier frequency values that have been read out. The method and the apparatus of the present invention can thereby be implemented, for example, in a mobile or base station of a mobile radiotelephone system.

When editing the random sequence of a plurality of n possible carrier frequency values 1 through N of the table, a random sequence of a plurality k of possible, different carrier frequency values is thereby respectively generated for each sub-group, these being written into the corresponding addresses of the respectively sub-group of the table, whereby $k \cdot n = N$ applies.

When setting up a connection, for example between two mobile radiotelephone units like a base station and a mobile station, a carrier frequency is sampled first. Subsequently, a decision is made as to whether a specific message was received on this carrier frequency during a specific time span. When the decision is negative, a new carrier frequency is selected and this new carrier frequency is

sampled. When the decision is positive, the table is edited upon employment of the message. In particular, the random sequence is thereby generated proceeding from the position at which the mobile radiotelephone unit that sent the specific message is also located at the moment, so that the random sequences of the two mobile radiotelephone units are synchronized.

For synchronization of, for example, two mobile radiotelephone units, a carrier frequency is first sampled. A decision is then made as to whether a specific message was received on this carrier frequency during a specific time span. When the decision is negative, a new carrier frequency is selected and this new carrier frequency is sampled. When the decision is positive, the address corresponding to this carrier frequency is sought in the table, and the carrier frequency values are periodically repeatedly read out proceeding from this address.

When only a part M of the possible N carrier frequency values fx are read from the table, only a part j of the possible k carrier frequency values are read from each sub-group, whereby the remaining k-j carrier frequency values are employed for replacing disturbed carrier frequencies of the j carrier frequency values in the respective sub-group, and whereby $j \cdot n = M$ applies. Before the periodically repeated readout, each sub-group of the table can be updated from the k-j carrier frequency values upon replacement of the carrier frequency values that correspond to disturbed carrier frequency values. As a result thereof, it is assured that, even given a plurality of usable carrier frequencies that fluctuates over time, the aforementioned FCC part 15 rules can be adhered to. For example, N is equal to 96 and M is equal to 78 for the case of FCC part 15. n=6 sub-groups can then be provided, whereby k = 16 and j = 13 apply.

The aforementioned method steps are respectively implemented in corresponding devices or, respectively, means in an inventive apparatus.

The invention is now explained in greater detail on the basis of an exemplary embodiment and with reference to the accompanying drawings. Shown are:

Fig. 1 a mobile radio telephone transmission system with an inventive fixed station;

Fig. 2 a time frame of a data transmission standard as employable given the present invention;

Fig. 3 details of the internal structure of an inventive base station;

Fig. 4 a schematic illustration of a frequency hopping spread spectrum system, particularly for the case of a jammer-evasion mode as well; and

Fig. 5 shows a table from which carrier frequency values within each sub-group are periodically repeatedly randomly read, whereby the sub-groups are read out in a specific sequence;

Fig. 6 shows a flow chart that shows a method for synchronizing, for example, two mobile radial telephone units;

Fig. 7 shows a flow chart that shows a method for setting up a connection between, for example, two mobile radial telephone units;

Fig. 8 shows a table from which respectively one part of the possible carrier frequency values is read out within each sub-group;

Fig. 9 shows a flow chart that illustrates a method for the synchronization of, for example, two mobile radio telephone units, whereby disturbed carrier frequency values can be replaced by non-disturbed carrier frequency values;

Fig. 10 shows a flow chart that illustrates a method for setting up a connection between, for example, two mobile radio telephone units, whereby disturbed carrier frequency values can be replaced by non-disturbed carrier frequency values;

Fig. 11 shows a table whereby only a part of the possible carrier frequency values within each sub-group are read out, whereby the remaining part of the carrier frequency values within each sub-group that are not read out is employed for replacing disturbed carrier frequency values;

Fig. 12 shows a table, whereby a disturbed carrier frequency of the part read out within a sub-group is replaced by a non-disturbed carrier frequency value; and

Fig. 11 shows a table, whereby another disturbed carrier frequency value in the part of the sub-group read out is replaced by a non-disturbed carrier frequency value.

With reference to Figure 1, the general structure of a mobile radio telephone transmission shall be explained first. As generally standard, the arrangement for radio transmission of data comprises a fixed station 1 and a plurality of mobile parts (mobile stations), cordless telephones 2, 3... . The fixed station 1 is connected to the fixed network with a terminal line 10. An interface means (not shown) can be provided for communication between the fixed station and the terminal line 10. The fixed station 1 comprises an antenna 6 with which, for example, a communication with the mobile part 2 occurs via a first radio transmission path 1 or with the mobile part 3 via a second radio transmission path 9. The mobile parts 2, 3...comprise a respective antenna 7 for the reception or, respectively, the transmission of data. In Fig. 1, the condition is schematically shown wherein the fixed station 1 actively communicates with the mobile part 2 and thus exchanges data therewith. The mobile part 3, in contrast, is in what is referred to as the idle locked mode wherein, standby-like, it waits for a call from the fixed station 1. In this condition, the mobile part 3 does not communicate with the fixed station 1 in the actual sense but receives the data of, for example, a time slot from the fixed station 1 at periodic intervals in order to be able to resynchronize its carrier frequencies fx.

The internal structure of the fixed station 1 is schematically shown in Fig. 1. The voice information data are supplied to a RF module 4 that is driven by a carrier frequency sequence unit. The exact structure of an inventive fixed station 1 shall be described later.

With reference to Fig. 2, a transmission standard shall now be explained of a type that can be employed given the present invention. As can be seen from Fig. 2, data are transmitted on a plurality of carrier frequency fx - 10 thereof being shown - in chronological succession in a plurality of time slots, 24 time slots Zx in the illustrated case, being transmitted in a time-division multiplex method in TDMA (time division multiple access). In the illustrated case, work is thereby carried out in duplex mode, i.e. following the transmission of the first 12 time slots Zx, a switch is made to reception and the twelve time slots (Z13 through Z24) are received from the fixed station in the opposite direction.

When what is referred to as the DECT standard is employed for the transmission, the time duration of a time frame amounts to 10 ms and 24 time slots Zx are provided, namely 12 time slots for the transmission from the fixed station to mobile parts and another 12 time slots Zx for the transmission from the mobile parts to the fixed station. According to the DECT standard, ten carrier frequencies fx are provided between 1.88 GHz and 1.90 GHz.

Of course, other frame structures are also suitable for employment in the present invention, for example those wherein the number of time slots per frame is cut in half compared to the DECT standard.

The present invention is particularly employed for transmissions in what is referred to as the 2.4 GHz-ISM (Industrial, Scientific, Medical) frequency band. The generally accessible ISM frequency band comprises a bandwidth of 83.5 MHz. According to the rule FCC part 15, at least 75 carrier frequencies must be distributed over these 83.5 MHz. A division of the bandwidth of 83.5 MHz onto 96 carrier frequencies is especially advantageous, i.e. a channel spacing of 864 kHz. The aforementioned frequency bands and standards are cited merely as examples. A fundamental precondition for an applicability in the present invention is merely that what is referred to is a frequency hopping spread spectrum is employed, i.e. that a plurality of carrier frequencies are available and that the carrier frequency selected for the transmission is changed from time to time. A precondition for such

a change is that the data are transmitted in time slots Zx (time-division multiplex method). Thus, for example, the DECT standard is suitable, as is any other modified standard based on this DECT standard.

With reference to Fig. 3, the internal structure of an inventive fixed station 1 shall now be explained in greater detail. As can be seen in Fig. 3, information data are supplied to the RF module 4 when transmission is to be carried out from the fixed station 1 to a mobile part 2, 3...with the antenna 6, and the HF module 4 outputs information data when data when data are received from mobile parts. The RF module 4 modulates the digitally encoded information data onto a carrier frequency fx. The carrier frequency fx to be currently employed is thereby prescribed by a carrier frequency sequence unit, which is referenced 20 overall. An acquisition means 24 to which the demodulated signal is supplied from the RF module 4 is provided in the carrier frequency sequence unit 20. Disturbance thereby means that either a disturbance in the actual sense or an occupancy by some other transmitter is present. A disturbance in the sense the present specification can thus be acquired in that a received signal is demodulated on a carrier frequency and acquired as to whether a signal level is present on this carrier frequency or not. A disturbed carrier frequency is thus a carrier frequency onto which a signal is modulated that exceeds a specific threshold.

Alternatively to the blocking, the A-CRC value, the X-CRC value, a loss of synchronization or the RSSI value can be utilized.

On the basis of the demodulated signal from the RF module 4, for example, the acquisition means 24 thus determines how high the signal part modulated onto a specific carrier frequency fx is. When the acquired signal part lies above a predetermined limit value, the acquisition means 24 outputs a disturbance acquired signal to an inhibit/enable unit 21. Dependent on the disturbance acquisition signal from the acquisition means 24, the inhibit/enable unit 21 forwards an inhibit/enable information to a processor 23. This inhibit/enable information indicates which of the carrier frequencies fx are inhibited or,

respectively, re-enabled due to the acquisition of a disturbance by the acquisition means 24, as shall be explained in later.

The acquisition means 24 and the inhibit/enable means 21 thus creates an independent procedure with which disturbed frequencies can be inhibited and re-enabled. In addition to being supplied with the inhibit/enable information from the inhibit/enable unit 21, the processor 23 is supplied with a sequence from a random generator 22. On the basis of a [...] in the implied random algorithm, the random generator 22 generates a randomly distributed sequence of carrier frequency values within the useable frequency band in order to store a random sequence of carrier frequency values in a table 25 of the processor. The random generator 22 thus implements a procedure independent of the procedure of frequency blocking for the case of a disturbance. During operation, the processor 23 serially reads the carrier frequency values from the table and, finally, outputs a drive signal to the RF module 4 that prescribes the carrier frequency value to be employed for the RF module 4.

The processor 23 comprises a table 25 provided in a memory whose function and administration shall be explained later.

With reference to Fig. 4, the operation of a fixed station 1 or, respectively, the method shall be explained in greater detail. As shown in Fig. 4, for example, a carrier frequency f1 is employed during a frame Rx of a mobile radio transmission, as shown shaded in Fig. 4. This frequency f1 is thus the first value of the random sequence stored in the table that is supplied to the processor 23, which in turn correspondingly drives the RF module 4. Let it be assumed for the frame R2 that the table 25 prescribes a frequency hop P1 onto a carrier frequency f3 on the basis of the sequence stored in it.

Let the case now be assumed that the acquisition means 24, for example in a prior transmission, has acquired that the carrier frequency f2 is disturbed, and the acquisition means 24 has thus forwarded a corresponding disturbance signal to the inhibit/enable unit 21 that in turn indicates an inhibit of the frequency f2 to the

processor 23. Let it also be assumed that the random generator 22 prescribes the carrier frequency f2 previously acquired as disturbed on the basis of its identified sequence for the frame R3. Proceeding from the coincidence of the prescribed carrier frequency f2 according to the sequence of the random generator 22 and, simultaneously, the inhibit signal from the inhibit/enable unit 21 for the same carrier frequency f2, the processor 23 now replaces the carrier frequency f2 that was actually prescribed but was acquired as disturbed for the frame R3 by a carrier frequency that was not acquired as disturbed by the acquisition means 24, for example the carrier frequency f4, as indicated by the frequency hop arrow P3. Instead of the carrier frequency 2 actually prescribed by the sequence, thus, the RF module 4 is driven onto the alternate carrier frequency f4. By replacing the carrier frequency acquired as disturbed, thus, a modified sequence of carrier frequencies is created. The modified sequence thereby comprises only undisturbed carrier frequencies. As a result thereof that a carrier frequency acquired as disturbed is replaced and not skipped, the positions of the undisturbed carrier frequencies in the modified sequence upon transition to the following carrier frequency is not modified compared to the original sequence.

The basis of this modified sequence composed of only undisturbed carrier frequency fx is thus formed by two superimposed, mutually independent procedures (table 25 or, respectively, inhibit/enable unit 21). This inhibit can be in turn canceled by the inhibit/enable unit 21 as soon as a renewed acquisition by the acquisition means 24 indicates that the previously disturbed carrier frequency is now no longer disturbed. In this case, the inhibit/enable unit 21 provides an enable signal to the processors 23 that indicates that the processor 23 now no longer need replace the previously disturbed carrier frequency by a different carrier frequency.

Alternatively, the inhibit/enable unit 21 can automatically output an enable signal to the processor 23 without renewed acquisition by the acquisition means 24 as soon as a predetermined time duration has expired. Each of said procedures thus independently assures that the entire, predetermined frequency

spectrum is utilized uniformly distributed. Standards are thus adhered to by the adaptation of the times in the procedure for inhibiting frequencies.

Let the U.S. rule FCC part 15 be cited as an example of such a standard. This rule prescribes that at least 75 different frequencies must be used given a frequency hopping spread spectrum system within a time span of thirty seconds. Each frequency is thereby allowed to be used for a maximum of 0.4 seconds in 30 seconds. Over and above this, all frequencies must be used equally distributed on average.

The fixed station 1 is the master in the frequency allocation, i.e. the random generator in a mobile part is initialized at the beginning of a connection setup with the status of the random number generator 22 of the fixed station 1. Subsequently, the same random number generator 22 in the mobile part generates the same random sequence of carrier frequency values as that stored in the table 25 of the base station and likewise stores it in a corresponding table 25. The mobile stations thereby comprise a very similar structure as the base station shown in Figure 3. The mobile stations in fact do not comprise the acquisition means 24 and the inhibit/enable means 21 but do comprise the random number generator 22 and the processor 23 with the table 25 as well as the RF module 4. It is also conceivable that the mobile station acquires the disturbed frequencies and informs the base or, respectively, fixed station. The present invention can thus be applied or, respectively, implemented both in a base station as well as in a mobile station.

The procedure for frequency blocking that is implemented by the acquisition means 24 and the inhibit/enable unit 21 employs a unidirectional protocol on the air interface during the entire connection time between the fixed station 1 and a mobile part 2, 3... . When the acquisition means 24 finds one of the ultimately possible frequencies fx of the fixed station 1 to be disturbed, then the fixed station 1 thus informs all mobile parts with which it is maintaining an active connection that this disturbed frequency - when it is read from the table - is to be

replaced by another carrier frequency acquired as being not disturbed. The frequency inhibit is in turn canceled by the inhibit /enable unit 21 when the inhibited carrier frequency is again suitable for the transmission or, respectively, when it was inhibited for longer than a previously defined time.

It can be seen in Fig. 3 that, for example, a table 25 provided in a memory is allocated to the processor 23. With reference to Fig. 3 as well as to Fig. 5 through Fig. 13, it shall now be explained how the carrier frequencies fx are inventively offered. As can be seen in Fig. 5, all N carrier frequencies fx available overall are entered into a table 25, for example 96 carrier frequencies fx. The illustrated distribution of the carrier frequency values is thereby only by way of example, and arbitrary other distributions can be selected.

The offering of the carrier frequencies fx from the table 25 is thereby shown in Figures 5 through 7 given the assumption that all N carrier frequencies fx that are available are employed for the transmission of data and no disturbance is present. Figure 5 shows the table 25 stored in the processor 23. Each address 1 through 96 has a corresponding carrier frequency fx allocated to it, whereby all 96 carrier frequencies employed are different. As indicated in Figure 5, the table 25 is subdivided into n sub-groups. In the illustrated example, wherein the table contains N=96 carrier frequency values, the table 25 can thereby be subdivided into n=6 sub-groups of k=16 carrier frequency values each. Within each sub-group, the carrier frequency values are successively sequentially read out, i.e. in the sequence of their addresses. The sub-groups within the table 25 are thereby read out in a specific sequence, for example in the sequence of first sub-group, third sub-group, fifth sub-group, sixth sub-group, fourth sub-group and, last, second sub-group. The indicated sequence has advantages in view of the frequency hops. It supplies a maximum frequency hop of 47 carrier frequency values (3·16-1 carrier frequency values), whereby the minimum frequency hop distance amounts to 17 carrier frequency values (16+1 carrier frequency values).

On the basis of a random number sequence generated by the random number generator 22, the carrier frequency values are thereby written into the n sub-

groups of the table 25. A random sequence of carrier frequency values is thereby first written into the first group until this is full, then into the second sub-group, etc. During the operation, the carrier frequency values fx are serially read out within each sub-group, whereby the sub-groups are successively read out in a specific sequence, for example the aforementioned sequence. The carrier frequency values that are read out are thereby converted into corresponding carrier frequencies in the RF-module and employed for the transmission of data. The specific sequence in which the sub-groups are successively read out from the table 25 can, in addition to the above-described, advantageous sequence, be any other suitable sequence. As a result of the above-described readout method, the calculating outlay in the respective mobile radiotelephone unit is considerably reduced during operation, since a new carrier frequency or, respectively, a new carrier frequency value fx need not always be determined. The random sequence of carrier frequencies fx in the table is respectively generated upon setup of the connection between mobile radiotelephone units and written into corresponding tables 25. Subsequently, the carrier frequency values written permanently into the table are accessed upon transmission of data, these being read out in the inventive way.

For example, each base station of a mobile radiotelephone system can comprise a random sequence of carrier frequency values fx in its table 25 that is allocated exclusively to it. A shift register or the like can be employed for generating the random sequence of carrier frequency values in the random number generator 22. When a connection is set up with a base station, a mobile station receives a specific message from the base station that initializes the generation of the random sequence of carrier frequency values fx, so that the identical table 25 of carrier frequency values fx as in the base station is generated.

Figure 6 first describes the synchronization of mobile radiotelephone units, for example the synchronization of a mobile station with a corresponding base station. It is thereby assumed that the connection has already been set up, i.e. that the random sequence of carrier frequency values fx has already been generated by the random number generator 22 in the mobile station and stored in the table 25 of the processor 23. Figure 6 shows a flowchart that explains the synchronization of, for

example, a mobile station with a base station. A corresponding means in the processor 23 is allocated to each of the method steps shown in the flowchart of Figure 6. In other words, each method step shown in the flowchart of Figure 6 is implemented in a corresponding means in the processor 23. The same is true of the method steps shown in the flowcharts of Figures 7, 9 and 10.

When synchronizing, a carrier frequency fx is first sampled in a corresponding means in a step 26. The sampled carrier frequency thereby corresponds to one of the carrier frequency values fx already stored in the table 25. In a step 27, a decision or, respectively, determination is made in a corresponding means as to whether this carrier frequency was received during a specific time span. When the decision is negative, for example since the carrier frequency is disturbed, a new carrier frequency is selected -- as shown in step 28 -- and this new carrier frequency is sampled. Advantageously, this new carrier frequency is selected from a different sub-group than the carrier frequency sampled first. When the decision in step 27 is positive, the address corresponding to this received carrier frequency is sought in the table 25, namely in a corresponding means of the processor 23 in a step 29. In a step 30, the random sequence of the carrier frequency values fx stored in the table 25 is read out in the inventive way in a corresponding means proceeding from this address. No additional information about the frequency hopping algorithm is thus needed during synchronization, since no modifications occur in the periodically repeated frequency value table 25.

Figure 7 shows a flowchart for explaining the setup of a connection between mobile radiotelephone units. The illustrated method steps are implemented in corresponding devices in the corresponding mobile radiotelephone unit. At the beginning of the setup of a connection, for example of a mobile station with a base station, a specific, selected carrier frequency is first sampled in a corresponding means in a step 31. In a step 32, a determination respective decision is made in a corresponding means as to whether a specific message was received on this sampled carrier frequency. The specific message can, for example, be the N_t message in the A-field of the DECT standard. Other, corresponding messages can be used in other standards. When it is found in the step 32 that the specific message was not received,

then, following the laps of a specific time duration that is determined in a step 33 in a corresponding means, a new carrier frequency, which is sampled, is selected in a following step 34 in a corresponding means. Advantageously, the new carrier frequency is selected from a different sub-group than the first sampled carrier frequency. The steps 32 and 33 can thereby be implemented in a single means.

When it is decided in step 32 that the specific message was received, the table 25 is generated in a corresponding means in a step 35. The various carrier frequency values are thereby generated in a random sequence by the random number generator 22 and written into the table 25 by sub-groups. The specific message or, respectively, a part thereof can be employed for generating the random sequence, it being thus assured that, for example in a mobile station, the same random sequence of carrier frequency values fx is written into the table 25 as is also present in the corresponding table 25 in the allocated base station. In a step 36 in a corresponding means, the carrier frequency values fx are then periodically repeatedly read out from the table 25 in order to transmit data in the corresponding carrier frequencies.

From the specific message received in the sampled carrier frequency, the mobile station thereby knows the address of the table 25 at which the base station is located, and, proceeding from this address, can read out the following carrier frequency values fx synchronously with the base station.

In Figures 8 through 13, only a part M, for example 78, of the carrier frequency values stored in the table 25 in the mobile stations are periodically repeatedly read out and employed for the transmission of data. The remaining part N-M = 96-78 = 18 of the carrier frequency values in the table 25 is employed for replacing disturbed carrier frequencies. As was explained with reference to Figure 3, for example, the disturbed carrier frequencies are identified by the respective base station. The information about the disturbed carrier frequencies is communicated to the respective mobile stations from the allocated base station, whereupon the disturbed carrier frequencies are replaced by non-disturbed carrier frequencies.

As shown, for example, in Figure 8, j = 13 carrier frequency values are sequentially read out within each sub-group, whereby the remaining k-j = 16-13 = 3 carrier frequency values of each sub-group are employed for replacing disturbed

carrier frequencies in the j carrier frequency values. In the illustrated example, the 96 carrier frequency values of each table 25 are subdivided into 6 sub-groups of 16 carrier frequency values each. Data or, respectively, information are thus transmitted overall in $M = j \cdot n = 13 \cdot 6 = 78$ carrier frequencies, so that the minimum rule of FCC part 15 is met. The remaining 18 carrier frequency values in the last three addresses of each sub-group are only employed for transmission of data when one of the carrier frequencies of the first 13 addresses in each sub-group are recognized as disturbed and indicated as such by the respective base station.

However, the generation of the random sequence of carrier frequency values for each sub-group also ensues such here that all 16 carrier frequency values for each sub-group are generated in a random sequence by the random number generator 22 and are stored in each sub-group of the table 25, whereby the sub-groups are successively filled up. Each carrier frequency fx is thereby contained only a single time in the table 25. When one of the carrier frequencies of the first 13 carrier frequencies of a sub-group employed for the transmission is recognized as disturbed, then the base station sends the mobile station a corresponding message for replacing the disturbed carrier frequency with a non-disturbed carrier frequency from the last three carrier frequency values of the corresponding sub-group. As a result thereof, disturbed frequencies can be avoided in the transmission. When more than 18 carrier frequencies are disturbed, the disturbed carrier frequencies that are employed produce a periodic background noise.

The methods for synchronization and setup of a connection of a mobile station and a base station that are shown in the flowcharts of Figures 9 and 10 essentially correspond to the method described in Figures 6 and 7, whereby, in order to avoid repetitions, respectively identical method steps are referenced with the same reference characters.

Figure 9 shows a flow chart that explains the method steps for the synchronization of a mobile station with a base station when only 78 carrier frequency values fx are periodically repeatedly read out from the table 25. The steps 26 through 30 thereby correspond to the steps shown in Figure 6 and are also implemented here in corresponding devices in the processor 23. In the synchronization method

according to Figure 9, an additional method step 37 is implemented in a corresponding means following the step 29 in which the address that corresponds to the sampled and received carrier frequency is found in the table 25. A specific message with which the table 25 is updated is received from the base station in the step 37. This means that the base station, when it detects a specific carrier frequency in a sub-group as being disturbed, replaces the corresponding carrier frequency value in its own table 25 with a non-disturbed carrier frequency value from one of the last three addresses of the sub-group and communicates this information to the mobile station. The mobile station replaces the same carrier frequency value, so that -- since the tables 25 of the base station and the mobile station are identical -- the carrier frequency values periodically repeatedly read out from the table 25 in the mobile station continue to coincide exactly with those of the base station. In the DECT standard, the specific message for updating the table 25 can, for example, be the P_t or M_t message of the A-field. After the updating of the table 25 in the step 37, the carrier frequency values are read out from the table 25 in their updated form. Differing from Figure 6, however, only 78 of the 96 available carrier frequency values are employed.

Figure 10 shows a flowchart that explains the setup of a connection between a mobile station and a base station. The flowchart shown in Figure 10 comprises essentially the same method steps as the flowchart shown in Figure 7, whereby, however, a step 38 for updating the table 25 is also additionally inserted here. The method steps 31 through 36 correspond to the method steps shown in Figure 7. All method steps shown in the flowchart in Figure 10 are implemented in corresponding means in the processor 23 of the mobile station. Following the step 35 wherein the table 25 was produced with the random number generator 22, the mobile station receives a specific message for updating the table 25 in order to replace disturbed carrier frequency values from the addresses 1 through 75 with non-disturbed carrier frequency values from the addresses 76 through 96. Here, too, the specific message for updating the table 25 can be the P_t or M_t message of the A-field in the DECT standard.

Figures 11 through 13 show how disturbed carrier frequency values from the sequentially read first 13 addresses of each sub-group are replaced by non-disturbed carrier frequency values from the last three addresses of the respective sub-group that have not been read out. Figure 11 shows a table 25 with six sub-groups of 16 carrier frequency values each. The first sub-group contains a random sequence of 16 carrier frequency values fx in its addresses 1 through 16. Of these 16 carrier frequency values, 13 carrier frequency values are sequentially read out from the addresses 1 through 13. When the base station finds, for example, that the carrier frequency that corresponds to the carrier frequency value f_{27} that is stored in address 3 of the first sub-group of the table 25 of the base station and of the mobile station is disturbed, it sends this information to the mobile station simultaneously with the instruction to interchange the carrier frequency value f_{12} located in the address 16 of the first sub-group with the carrier frequency value f_{27}.

Figure 12 shows an updated table 25 wherein the carrier frequency values f_{12} and f_{27} have changed places in the first sub-group of the table 25 of Figure 11. The first 13 carrier frequency values in the addresses 1 through 13 in each sub-group are thus always read out sequentially, whereby the sub-groups are successively read out in a specific sequence, as was set forth above. Even when disturbed carrier frequencies are found, the first 13 carrier frequency values continue to be read out from each sub-group, whereby the disturbed carrier frequency values are replaced with non-disturbed carrier frequency values from the last three addresses of the corresponding sub-group.

When the base station subsequently finds that the carrier frequency that corresponds to the carrier frequency value f_{27} is no longer disturbed but and that the carrier frequency corresponding to the carrier frequency value f_{54} is now disturbed, it first changes the carrier frequency value f_{27} back into its address 3 and correspondingly changes the carrier frequency value f_{12} back to its address 16 and also provides the mobile station with the corresponding instruction to do this. Subsequently, the next disturbed carrier frequency value f_{54} is interchanged from its address 13 with the carrier frequency value f_{54} from address 16.

When they are no longer disturbed, the original carrier frequency values are thus always written back onto their old locations or, respectively, into their old addresses first before new disturbed carrier frequency values are replaced.

The numbers for the carrier frequency values stored in the table 25 and read out therefrom that are indicated in the present specification are merely exemplary. Other arbitrary values can be employed dependent on the standard to be met.